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*Original Contribution*

# PROPRIOCEPTIVE TRAINING FOLLOWING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

**N. Taneva-Georgieva***

Department of Kinesiotherapy, Physical Medicine and Sport Trakia University, Faculty of Medicine, Stara Zagora, Bulgaria

**ABSTRACT**

The aim of the present study was to evaluate the efficiency of proprioceptive training in patients after ACL reconstruction surgery. The study cohort comprised 35 patients with arthroscopic patellar tendon reconstruction. The patients began their kinesiotherapy from the maximum protection phase to complete restoration of lower extremity function and pre-traumatic locomotor activity level. A number of methods for functional study and evaluation of the patient cohort were applied to determine the initial status and the results at the end of rehabilitation procedures. According to the applied kinesiotherapy protocol, patients were allotted either to a control or to an experimental group. Both groups were submitted to a standardised programme enhanced by proprioceptive training in the experimental group. The results from the studies and analyses confirmed the positive effect of proprioceptive training for the reduction of congestion events and pain. A faster return to daily, professional and sports activities is achieved, which in turn improves the quality of life of patients after ACL reconstruction. Proprioceptive training is very efficient for the faster functional recovery of the lower extremity. The recovery period and necessary number of rehabilitation sessions are reduced. The early inclusion of proprioceptive training in rehabilitation protocol plays a key role for recovering to a previous level of locomotor activities.

**Key words:** proprioception, kinesiotherapy, stifle joint, anterior cruciate ligament

## INTRODUCTION

Anterior cruciate ligament (ACL) injuries affect mainly active young people. The etiological factors or their occurrence are extremely diverse, including genetics (1). The most frequent is sports activity. Almost 50% of all sports injuries affect the knee complex, and 78% of them are related to ACL damage. The mechanism of injury is related to hyperextension or hyperflexion with forced rotation of the lower leg on landing after a high jump. ACL rupture may be isolated, yet it is often combined with damage to other ligamentous structures of knee complex (2). The regenerative potential of the ligament is weak. For this reason, surgical treatment is often required (3). The long recovery from ACL injuries predisposes various complications. Most of them are consequences of hypokinesia – congestive events, muscle hypotrophy, limited range of motion, locomotor disorders, etc. The postural stability of the stifle joint and its proprioception are altered (4). At a later stage, degenerative changes, development of dynamic instability, impaired neuromuscular control, etc. are observed. (5). That is why the problem has an important social impact and requires constant updating of kinesiotherapeutic methods for recovery of patients and studies on individual means.

The accurate functional assessment of the initial condition of each patient plays a primary role in the recovery of traumatic ACL injuries. This, in turn, is a key element in the development of the individual kinesiotherapy programme due to the fact that it takes into account the pathokinesiological changes present after the rupture. The repeated performance of research methods allows monitoring of the achieved

***Correspondence to:** *N. Taneva-Georgieva, Department of Kinesiotherapy, Physical Medicine and Sport, Trakia University, Faculty of Medicine, Stara Zagora, Bulgaria, 11, Armeiska str.1, nora.taneva@trakia-uni.bg*

results and if necessary, correction of the methodology (6).

The effect of early lower extremity loading and the application of proprioceptive exercises after ACL reconstruction with an optimal protection of the healing structures are still controversial issues. Proprioceptive training begins 2 to 4 weeks after the surgical treatment and the resumption of independent walking (7). Proprioceptive exercises, by their nature, focus on somatosensory signals in the presence or absence of the visual analyser (8). Their early initiation has a beneficial effect on the postural stability of the stifle. (9) The inclusion of a *foam roller* improves the proprioception and knee function in general, and reduces pain (10).

**The aim of the present study is to evaluate the efficiency of proprioceptive training in patients after arthroscopic ACL reconstruction surgery.**

## MATERIAL AND METHODS

The study cohort comprised 35 patients with ACL surgery and patellar tendon reconstruction. The mean age of patients was 35 years. According to the applied kinesiotherapy protocol, the participants were divided into two groups: control and experimental. The control group consisted of 18 patients subjected to the standard kinesiotherapy recovery programme. For the 17 patients from the experimental group, enhanced proprioceptive training was included together with the standard kinesiotherapy recovery programme. The two groups were uniform with regard to sex, age, height and body weight without statistically significant differences. The patients began their kinesiotherapy from the maximum protection phase to complete restoration of lower extremity function and pre-traumatic locomotor activity level. A number of methods for functional study and evaluation of the study groups were applied for determination of the initial status and monitoring of recovery dynamics:

- Questionnaire survey of pain in patients including visual analogue scale (VAS) scores.
- Questionnaire survey of patients for determination of locomotor activity before the injury and the actual deficiency after ACL reconstruction.
- Anthropometric measurements – lower extremity circumference for detection of congestive events.
- Goniometry for evaluation of motility of lower extremity joints.
- Manual muscle testing (MMT) of lower extremity muscles for muscle strength evaluation.
- Statistical analysis of obtained data - Kolmogorov-Smirnov test; descriptive statistical analysis; analysis of between-group differences; Pearson's chi-square test ($\chi^2$ test).

The kinesiotherapy protocol of study groups was composed according to individual physical capabilities of patients, the results from performed functional tests and the specific recovery period. The patient's age, co-morbidities and pre-traumatic level of locomotor activity were also considered. The kinesiotherapy procedures were applied three times per week.

The means applied during **the maximum protection phase** are as followed:

- Oedema massage of lower extremities;
- Cryotherapy in the region of the stifle joint;
- TENS for 15 minutes in the stifle joint region using a transverse method;
- Positioning therapy of the injured limb **(Figure 1)**;
- Grade 1 and 2 mobilisation of the patella;
- Muscle inhibition techniques – post isometric relaxation of shorted lower limb muscles;
- Passive, active and assisted exercises;
- Isometric contractions for weakened muscles;
- Exercises in an open and closed kinetic chains;
- Training in walking with aids;
- Aerobic training on veloergometer.

**Figure 1.** Positioning therapy for restoration of stifle joint extension.

The patients from the experimental group were submitted to proprioceptive training of lower extremities on a stable support with and without involvement of the eyes **(Figure 2)**.

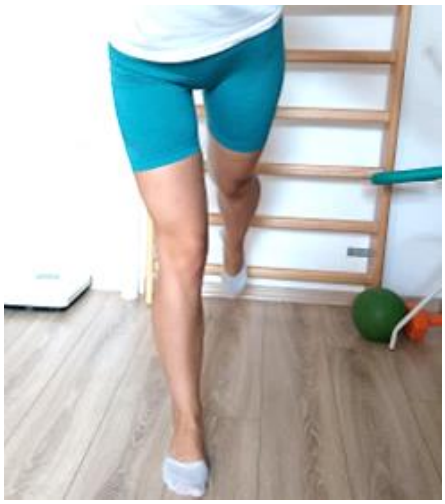

**Figure 2.** Proprioceptive training on a stable support.

The following techniques were used in both groups during the moderate protection phase:

- Selective massage of lower extremities
- Positioning therapy
- Joint mobilisation techniques
- Exercises in a closed kinetic chain with *fit ball*;
- Exercises against resistance;
- Stretching;
- Training in walking without aids

In the experimental group, proprioceptive training was applied apart the abovementioned means replacing the stable support with an unstable one. (**Figure 3**)

**Figure 3.** Proprioceptive training on a unstable support.

Kinesiotherapy and ergotherapy means during the minimum protection phase included:

- Stretching
- Exercises against substantial resistance
- Joint mobilisation techniques
- Plyometric exercises
- Exercises for speed and agility
- Specific sports activities

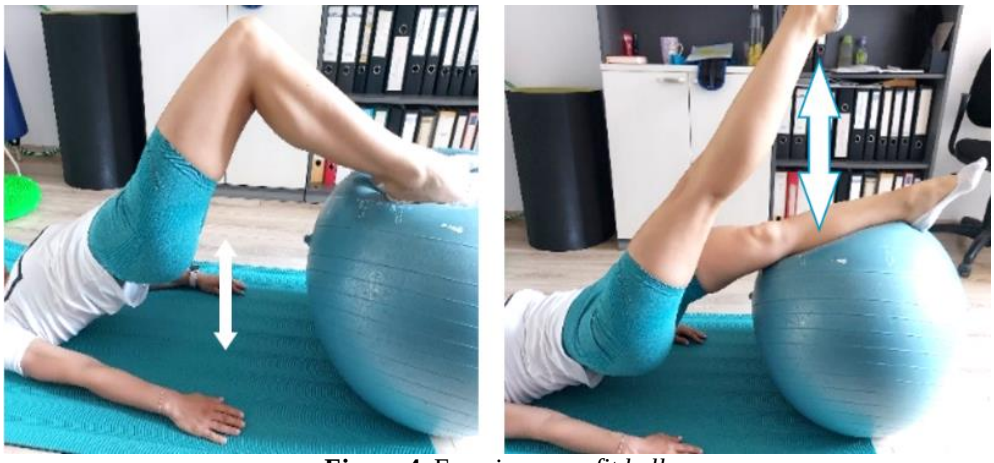

**Figure 4.** Exercises on a *fit ball*.

The experimental group method included again proprioceptive training on an unstable support without involvement of the eyes.

## RESULTS AND DISCUSSION

The effect of proprioceptive training on pain intensity and dynamics was monitored. To this end, the pain was quantified by VAS. Pain evaluation was performed three times during the different recovery phases. The comparison of the results of the two groups by the end of recovery period showed statistically significant differences in pain scores. In patients from the experimental group pain scores decreased for a significantly lower period of time, compared to the control group (**Figure 5).**

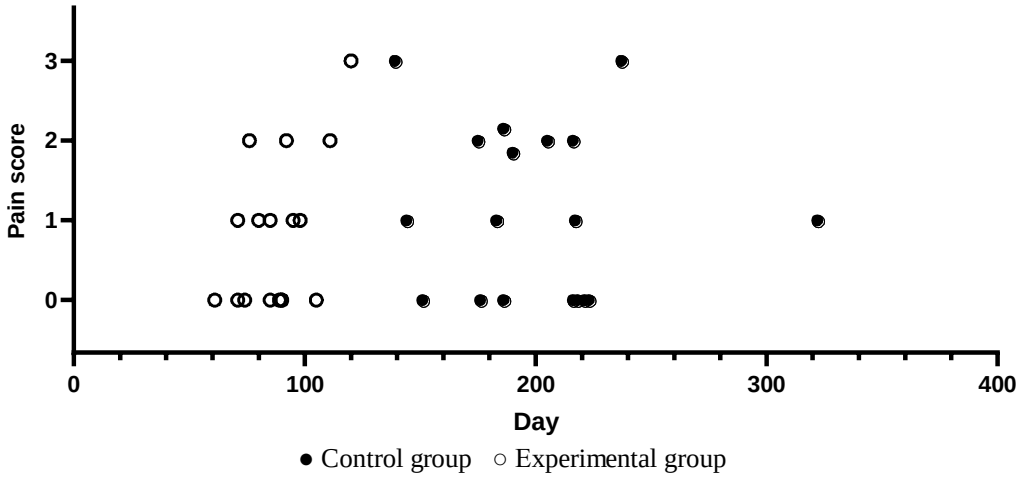


**Figure 5.** Pain dynamics at the end of the recovery period.

The results show that proprioceptive training results in faster reduction of pain intensity which reflects on the stifle range of motion, lower extremity muscle strength, improvement of the gait etc.

The stifle joint circumference was monitored from the maximum protection to the minimum protection phase. The values in both groups changed in a relatively similar manner, but the time for reduction of the oedema was different. In the experimental group, oedema reduction occurred faster than in the control group **(Figure 6).**

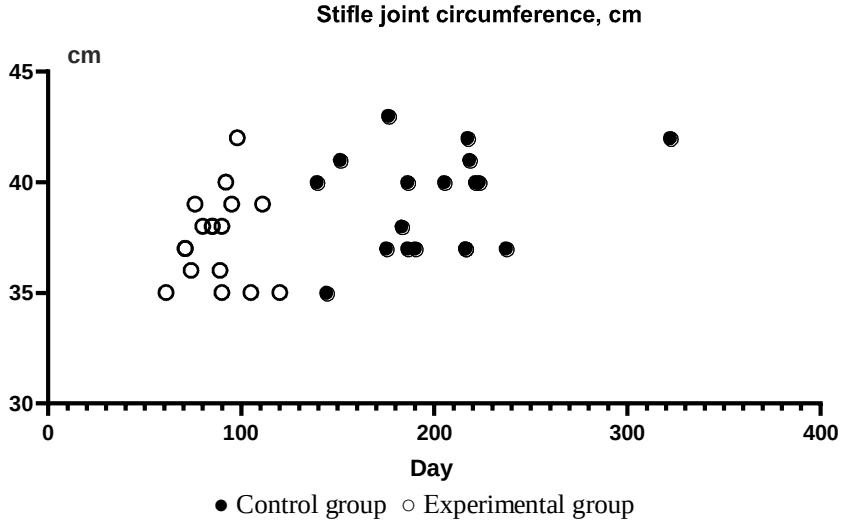


**Figure 6.** Dynamics of stifle circumference at the end of the recovery period.

The results indicated that the experimental kinesiotherapeutic protocol contributed to more rapid resolution of congestion events in the lower extremity, which also increased joint range of motion, use of the limb in daily activities and proper gait.

The analysis of goniometric data of the stifle joint showed again significant differences between the control and experimental subjects in terms of time needed for range of motion recovery **(Figure 7).**

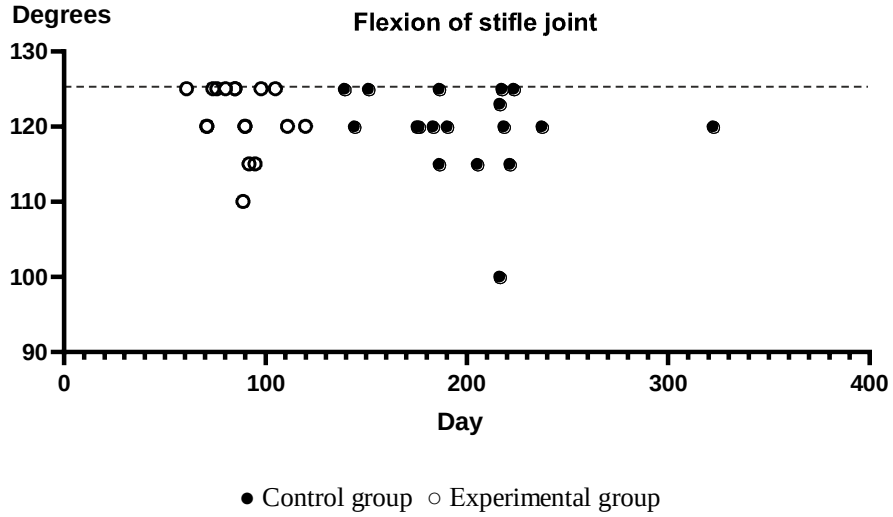


**Figure 7.** Dynamics of stifle joint flexion at the end of the recovery period.

Manual muscle testing was conducted for evaluation of changes in lower limb muscle strength. The three MMT tests allowed for muscle strength monitoring throughout the different recovery phases. During the maximum protection phase, muscle weakness of flexors and extensors were observed in both groups without statistically significant differences. The median MMT value of flexors in controls was 1.75, and in experimental patients: 2 ($P<0.0001$). The median MMT for extensors of both groups was 2 ($P<0.0001$). During the recovery process, muscle strength was restored to normal values ($P=0.0132$). Again, the experimental kinesiotherapy protocol was superior to the standard one as could be seen from the time needed for increase in muscle strength **(Figure 8).**

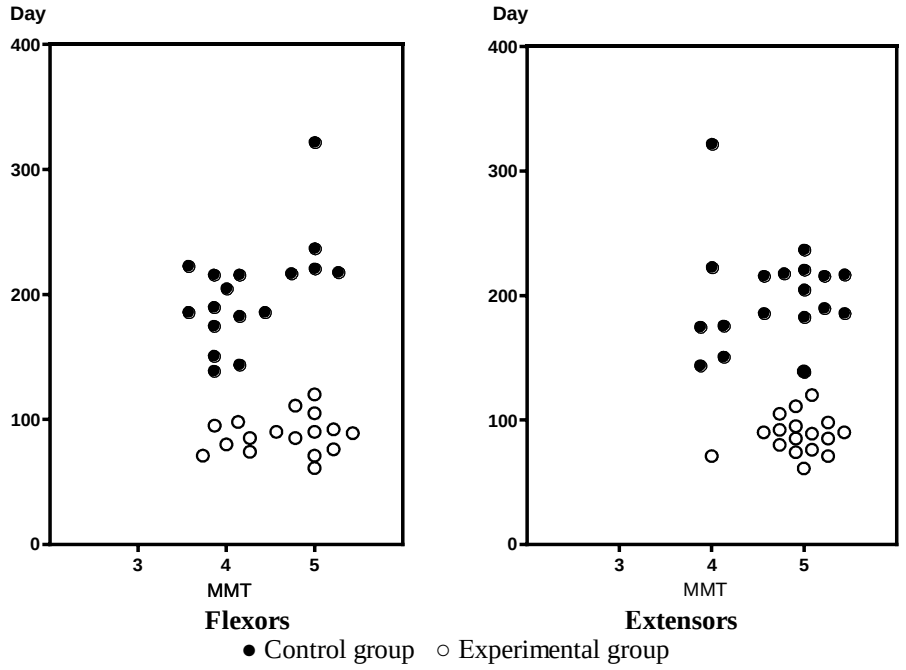


**Figure 8.** Dynamics of muscle strength of stifle flexors and extensors at the end of the recovery period.

The results confirmed that the experimental protocol was more efficient in terms of shortening the period of regaining the normal muscle strength level.

The results about the necessary number of rehabilitation sessions for recovering to a previous level of locomotor activity of patients and their return to daily life and/or sports activities were obtained from the monitoring of recovery dynamics in both groups. According to data, patients from the control group needed an average of 6 kinesiotherapy sessions to completely recover their functions, compared to 4 sessions in the experimental group **(Figure 9).** The between-group differences were highly significant (P<0.000001).

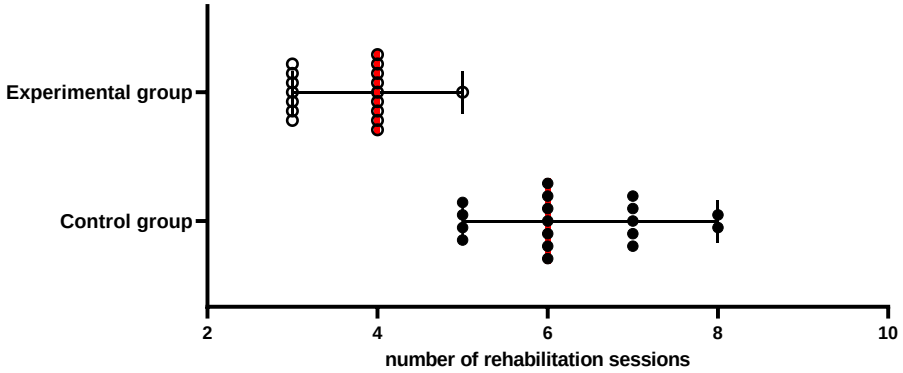


**Figure 9.** Number of necessary rehabilitation sessions in both groups.

## CONCLUSION

The accurate analysis of data from the performed functional measurements and studies demonstrates that:

- Proprioceptive training is very efficient for enhanced functional recovery of the lower extremity.
- A faster return to daily, professional and sports activities is achieved, which on turn improves the quality of life of patients after ACL reconstruction.
- Proprioceptive training contributes to a more rapid recovery of muscle strength, stifle range of motion and previous level of locomotor activity.
- Proprioceptive training is extremely efficient for the more rapid reduction of pain and congestion events.

- The recovery period is shortened, as did the necessary number of rehabilitation sessions.

The early inclusion of proprioceptive training in rehabilitation protocol plays a key role for recovering to a previous level of locomotor activities. A faster return to daily, professional and sports activities is achieved, which in turn improves the quality of life of patients after ACL reconstruction.

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